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# Analyzing Users' Perceptions on Solar Electrification: A Study on Villagers in off-grid Regions

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## Abstract

This empirical study sought to ascertain the perception of rural communities in Bangladesh about the development opportunities derived from the emergent adoption of solar home system (SHS). Using the semi-structured questionnaire, this study analyzed information gathered from one hundred and seventy one respondents drawn purposively from two villages locally known as Charking and Boalia, situated in the Noakhali and Shirajganj districts respectively. The survey was conducted between October, 2017 and January 2018 including field observations in the selected sites and in-depth interviews to facilitate the data collection process. Questionnaire items, which were primarily adopted from prior studies, measure the responses of the survey participants in a seven point Likert-scale ranging from 'strongly agree' to 'strongly disagree'. Since the study focuses more on exploring users' perception regarding SHS adoption, basic descriptive statistics of percentage, frequencies, and cross tab were incorporated in the analysis. Results of the study reveal that, household users in the off-grid rural locations benefit from the access to solar electricity through improvement in their living conditions and enhanced social status. In addition to this, the rural families avail convenient in-house lighting, security at night and better educational opportunities for the children. With this backdrop, findings of the study add value to the current literature on impact assessment of solar electrification and provide strategic insights for policymakers to promote the usage of renewable energy technology among the rural populations of the country.


**Keywords**: Rural Electrification, Solar Home System, Rural Households, Social Development.

# 1. Introduction

## 1.1. Background

In the densely populated country of Bangladesh, about 80% of the population resides in rural areas and among them 40% has no connection to the grid electricity (BBS, 2016). The country is still considered as one of the lowest electricity consumption nations in the world, despite its progress in electricity production from 122.43 kWh to 310 kWh during the years of 2003 to 2014 (World Bank, 2018). Majority of the rural inhabitants in the country suffer from access to sufficient supply of commercial energy, i.e. electricity that is required for socio-economic development (Khan, 2017). Per capita consumption of energy, as an indicator of the physical quality of life, remains very low in Bangladesh. In 2014, it was only 310.39 kWh (World Bank, 2014). The reason lies in the fact that it is not reasonable to expand supply of grid electricity to less populated areas. As conventional electrification to low-load rural and remote regions requires high transmission and distribution losses, and hence calls for heavily subsidized pricing of electricity (Mondal et al., 2010). In 2005, the government of Bangladesh declared its aspiring goal to provide universal access to electricity by the year 2020 (PSMP, 2005). In line of this, the government aims to generate 5% of the total power generation from renewable sources and by 2015 and 10% by 2020 (REP, 2008). The utilization of solar, hydro, biomass and wind energy technologies are intended to contribute a major share in achieving this target.

Since grid extension needs intensive capital investments, off-grid electrification by renewable energy (RE) offers an alternate solution for many low-demand households in the non-electrified and remote regions of the country (Laufer and Schafer, 2011). From the perspective of resource availability and user acceptance, solar photovoltaics (PV) technology is the most viable electrification option in the country relative to the other renewable energy sources (Islam et al., 2014; Najmul and Kumar, 2013). As a subtropical country, Bangladesh has daily solar radiation of 4–6.5 kW h m−2 (Hossain et al., 2017). This presents an opportunity of off-grid solar technology like solar home system (SHS) (Palit, 2013).

Household lighting is an essential need for household chores, extending work and study hours, and it allows household tasks and other social

activities. In the rural regions, the electricity demand is mostly dominated by home lighting loads that are inadequate to justify the considerable capital investments required to establish electricity generation and transmission infrastructure. Solar Home System (SHS) consists of photovoltaic (PV) technology converts sunlight directly into electricity. SHS offers a cost-effective mode of supplying electric power for lighting and appliances to remote off-grid households (Twidell and Weir, 2015). At present, various types of solar electric systems are available around the world; all of those consist of basically three main items: panels that turn sunlight into electricity; inverters which transform that electricity into alternating current to make it usable for general household appliances and batteries that store surplus electricity generated from the system. The rest of the system includes system components such as wiring, circuit breakers, and support structures.

The progression of renewable energy technology in Bangladesh for improving rural electrification indeed highlights the prospect of renewable sources or more specifically solar energy in the power and energy sector of the country (Najmul and Kumar, 2013). The next sections of the paper are organized as follows: Section two summarizes review of related literature, section three comprises of the research methodology, section four presents findings of the study and section five makes a discussion on the research outcomes. Lastly, conclusion and policy implications have been highlighted in section six followed by list of referred journals and articles reviewed in this research.

### 1.2. Objective of The Study

This study aims to examine the perceptions and opinions of rural households regarding the usage of solar home system. In addition to this, the study intends to:

a) Study the prospect of rural electrification through SHS
b) Analyze the users' perceptions about the usage of SHS
c) Identify the benefits of solar electrification in rural development

### 1.3. Methodology

This empirical study has been pursued by collecting primary data through structured questionnaire survey with 171 respondents who were selected by

purposive sampling. The inclusion criteria of the sample respondents is that the survey targeted those families who installed the system from the partner organizations of national RE program and they are using solar energy for household purposes with a duration of more than 6 months and above. Considering these, in between October 2017 to January 2018, the respondents got selected from the study locations as detailed below:

- 92 respondents were surveyed from the Charking village in Hatiya upazila of Noakhali district.
- 79 respondents participated in the survey from the village of Boalia in Ullapara upazila of Shirajganj district.

All items provided in the questionnaire were mainly compiled from prevailing literature related to the domain of the study. Additionally, some items in the questionnaire were included based on the personal interviews and filed observations that were undertaken prior to the data collection process. Since the study focuses more on understanding users' perceptions regarding the benefits and constraints in using SHS, the analysis incorporated basic descriptive statistics and crosstab results (Hossain et al., 2017; Das, 2013).

## 2. Literature review

### 2.1. Solar Electrification Program

SHS programs have been instigated in the country by two different distribution approaches. The initial approach was carried out by the Rural Electrification Board (REB), the state-owned utility service provider, established in 1977 (Wahi and Ahsan, 2012). REB operates under a license issued by Bangladesh Energy Regulatory Commission (BERC) and it is the concerned authority in the country for supplying grid-electricity in the rural communities (REB, 2018). During the initial stage of RE programs (the early 90s), REB disseminated SHS through the fee-for-service mode. In this approach, REB owned the systems that were installed at rural households and for using the electricity generated from the system; the rural users were required to pay a monthly service charge for using the systems (Asaduzzaman et al., 2013).

More recent and widely practiced approach for promoting SHS usage in rural Bangladesh is executed by the Infrastructure Development Company

Limited (IDCOL) formed by the Government of Bangladesh in 1997. IDCOL operates the SHS program with 56 collaborating organizations, referred as, Partner Organizations (PO).

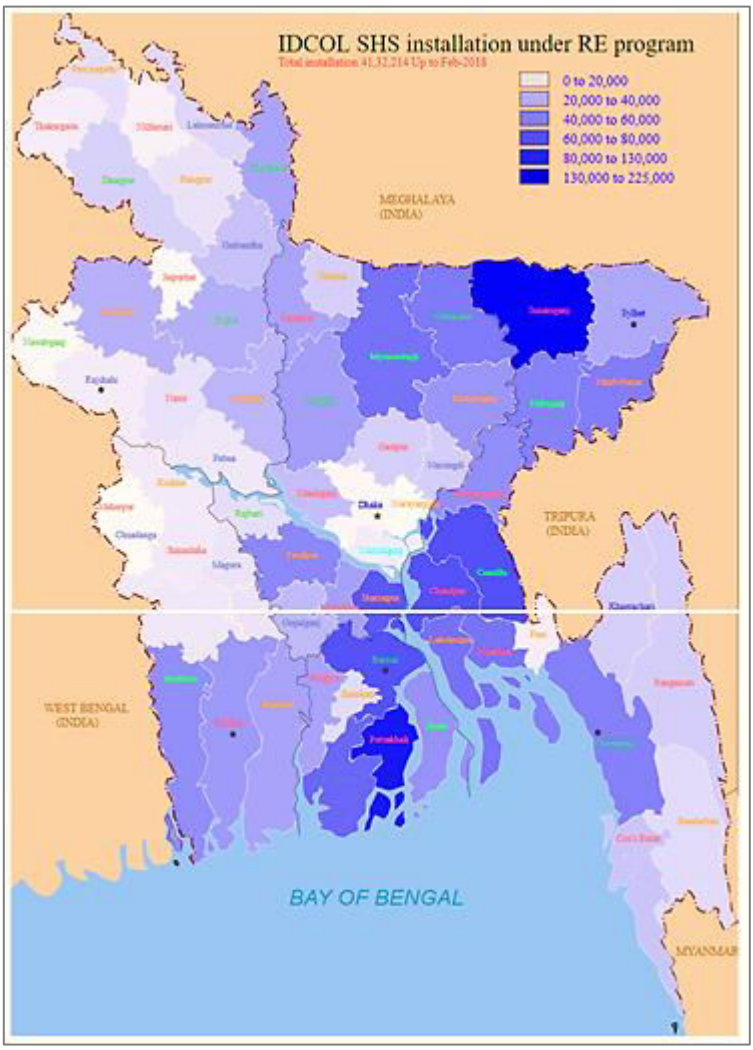


**Figure 1: SHS installation status under IDCOL Renewable Energy Program (Source: RE Program, IDCOL)**

These POs are commonly categorized as Non-Government Organizations (NGO) and Micro-finance Institutions (MFI) like Grameen Shakti, Rural Services Foundation, Srizony, TMSS, Bengal Solar etc. (IDCOL, 2018). These organizations procure the system components (panels, batteries, charge controllers etc.) and install the systems at the rural households. The POs employ their local networks and proficiency in micro-credit services to have greater access and acceptability in the rural and remote regions in order to make SHS affordable to the potential users. To avail the benefit of solar energy for reliable power generation, more than 4.13 million SHS has been installed in the country that supply electricity to 18 million beneficiaries (IDCOL, 2018) (Figure 1). In this backdrop, this study aims to analyze the rural household users' perceptions regarding the social benefits they avail from the adoption of SHS.

## 2.2. Implications of Solar Electricity in Rural Households

In the rural regions of the Bangladesh, electrification through SHS has received attention among the researchers by bringing positive outcomes like improving the living standard and economic productivity of the users (Chakrabarty and Islam, 2011). A growing number of research studies have focused on the impact of SHS programs in rural development. In these papers, the authors have assessed the link between the supply of energy services and resulting development in living standard. The studies outlined the benefits of SHS usage by emphasizing the decrease in households energy expenditures, improved health status and better income generation and productivity by prolonged working hours at night (Das, 2013; Kabir et al., 2010; Sovacool and Drupady, 2011; Islam et al., 2012; Momotaz and Karim, 2012; Komatsu et al., 2013).

These research papers recognize that SHS installation in rural Bangladesh usually gives positive outcomes for elevating the living standard of rural communities. In addition to this, the progress, prospect and scope of SHS programs were critically reviewed in existing studies. Most of these studies were focused in Sub-Saharan Africa and developing Asian countries (Mishra and Behera, 2016; Azimoh et al., 2015; Bo et al., 2015; Kassahun et al., 2015; Jitiwat and Tetsuo, 2013; Laufer and Schafer, 2011). The authors in these papers reviewed the rural electrification projects through solar power which is the leading decentralized technology applied to improve electricity access in underprivileged locations.

### 2.3. Challenges in SHS Usage

Despite the appealing features, solar PV systems do not yet have broad market acceptance due to the existing obstacles rising from the necessity of large-scale implementation. The main barrier is higher installation expenditure which results in the lack of affordability of the technology for the poor rural communities (Mishra and Behera, 2016; Komatsu et al., 2011; Asaduzzaman et al., 2013). In addition to this, limited awareness on RET and lack of program coordination are the other obstacles in accelerating the SHS program (Eronini, 2014; Sovacool and Drupady, 2011; Mondal et al., 2010; Ahammed and Taufiq, 2008; Kabuta et al., 2007). Along with these issues, during rainy and winter seasons, due to less availability of sunlight, the system suffers from the lack of adequate power generation, which consequently limits the usage of the electric appliances powered by solar technology (Hossain et al., 2017). These findings were developed by reviewing the related cases studies from Bangladesh, India, Sri Lanka, Thailand, Indonesia, Philippines, Ethiopia, South Africa and the Latin America. Due to these critical issues mentioned above, it has remained an obvious fact that the diffusion of RET in developing countries has been characterized as sluggish and urged the joint effort by the stakeholders including the policy makers, POs, component manufacturers and customer representatives. From this background, this study calls for research attention on understanding the implications of SHS usage from the perspective of the rural users to outline the opportunities and challenges in developing rural electrification.

## 3. Results and Findings

This section of the study highlights the opinions of the household users' of SHS from the study locations of Charking and Boalia villages to reveal the social benefits of solar electrification in the remote off-grid communities. In order to understand the background of the respondents, the demographic profile of the survey area and the respondents is presented in Table 1. As observed in Table 1, the sample respondents were comprised of 67% male and 33% female respondents. Majority of the respondent households (69%) have a family size of 5 to 7 members. All the female respondents are categorized as homemakers and the occupation of the male respondents are usually wage earners in agricultural and nonagricultural activities, and small business owners.

**Table 1: Demographic characteristics of the sample respondents**

| Demographic Factors | Frequency | Percentage |
|---|---|---|
| Gender | | |
| Male | 115 | 67% |
| Female | 56 | 33% |
| Occupation | | |
| Homemaker | 54 | 31.6% |
| Wage earning/service | 56 | 32.7% |
| Self-employed/Business | 40 | 23.4% |
| Farming | 10 | 5.8% |
| Others | 11 | 6.4% |
| Monthly household income (BDT) | | |
| Below 10000 | 64 | 37.4% |
| 10000 > 15000 | 69 | 40.4% |
| 15000 > 20000 | 29 | 17% |
| 20000 > 25000 | 3 | 1.8% |
| 25000 > 30000 | 3 | 1.8% |
| 30000 above | 3 | 1.8% |
| Family size | | |
| 2 to 4 members | 49 | 28.7% |
| 5 to 7 members | 118 | 69% |
| 8 to 10 members | 4 | 2.3% |
| SHS usage duration | | |
| Below 1 year | 15 | 8.8% |
| 1 year > 2 years | 40 | 23.4% |
| 2 years > 3 years | 41 | 24% |
| 3 years > 4 years | 52 | 30.4% |
| 4 years > 5 years | 18 | 10.5% |
| 5 years & above | 5 | 2.9% |
| Capacity of SHS installed | | |
| Below 20 watt | 16 | 9.4% |
| 20 watt > 40 watt | 49 | 28.7% |
| 40 watt > 60 watt | 43 | 25.1% |
| 60 watt > 80 watt | 45 | 26.3% |
| Above 80 watt | 18 | 10.5% |

Around 40.4 % respondents have monthly household income in between 10,000 taka to 15,000 taka and 37.4% earn below 10,000 taka. 28.7% respondents have installed SHS with the capacity of 20 watt to 40 watt and 26.3% households have the installed system capacity in between 60 watt to 80 watt as evident in Table 1. Again, 30.41% of the respondents have been using SHS for three to four years and 24% of the respondents are getting solar electricity for the duration of two to three years. Table 2 summarizes and reveals the results of crosstab analysis by indicating the significance of the implications of solar home system usage in reference to the selected demographic variables mentioned above. From the analysis, in reference to the family size of the respondents and SHS usage implications, it can be stated that a greater majority of the respondents (95.9%) agreed about the fact that due to solar electricity, their family can comfortably manage the household chores. This is also significant in the Chi-Square test where the calculated p value is 0.000 ($p<0.05$).

**Table 2: Results of Cross-Tab Analysis on Social Benefits of SHS**

| Demographic variable | Users' perceptions about the social implications of SHS usage | P value< .05 (Pearson Chi-Square) |
|---|---|---|
| Family size | Comfort in household chores with SHS | .000 |
| Gender of the respondent | Security at night with solar light | .026 |
| SHS usage duration | Children get longer study hours at night | .000 |
| Occupation | Access to information by tv/mobile | .003 |
| Respondent's household income | Recommending others about using SHS | .000 |

Considering the gender of the respondents, the greater majority, around 95.9% of the respondents (63.7% strongly agreed and 32.2% moderately agreed) opined that at night times, due to the presence of solar lights, they feel secured to move around in their locality. The findings are also evident through the Chi Square test with p value is .026. Again, from the perspective of duration of SHS usage, a greater number of the respondents gave their opinion (59.6% respondents strongly agreed and 33.3% respondents moderately agreed, p value of .000) towards the fact that with the presence

of solar lights at their home, their children can study for longer hours at night and thus their educational status has developed than before.

On the other hand, to shed light on the limitations of SHS, it was found that, only 8.1% respondents in the study locations agreed towards the fact that they can watch TV powered by SHS. In most of the cases, majority of the users (41.5% respondents) opined that they don't have the utility of information or entertainment through TV from solar electricity (p value is 0.003) due to the comparatively smaller capacity of installed SHS (20 watt to 40 watt) to power larger electronic equipment. However, since the installation of the system also enables mobile phone charging devices, the rural users can also charge and utilize their phones and thus avail the communication facilities and other socio-economic benefits of telecommunication. Thus considering the household benefits derived from the SHS, respondents from different income groups stated that (49.1% respondents strongly agreed and 44.4% respondents moderately agreed) they would like to suggest others in their neighborhood to use the system (p value is .000).

While assessing the users' satisfaction in the locations of Manikganj, Kishoreganj and Comilla, Komatsu et al. (2013) also opined about enhanced educational opportunities and better in-house lighting for rural communities resulting from solar electricity. In a developing nation like Bangladesh, the villagers are more prone to the health and safety threats comparing to the urban population (Asaduzzaman et al., 2013). In this situation, due to illuminated neighborhood with solar lights, theft and other illegal occurrences at night has declined in those areas. Thus, solar electrification bears a significant impact on the living condition of rural communities.

## 4. Discussions

### 4.1. Increasing the awareness on RET

To ensure technically sound usage of SHS, customer training and awareness programs should be carried out for the rural users to make them aware on the basic operations and durability of the system. This also requires demonstration of the technology to the rural population by organizing promotional campaigns and courtyard meetings which is regarded as an effective rural marketing tool.

### 4.2. Availability of solar accessories

To cater the electricity demand in the dispersed rural locations, the SHS program must address the availability of system components with the authorized dealers in local markets. In this regard, reviewing the existing supply chain scenario in different regions is needed that can be followed by designing the required distribution network and implementing the suitable supply chain strategy to assure the availability of solar equipment in the remote corners of the country. On the other hand, the open market sell of SHS and other related accessories should be regulated to streamline the deployment of SHS program across the country through the network of POs and their branch offices.

### 4.3. Customer service support

The POs and supervisory institutions should consider recruiting and training more customer service personnel to ensure proper maintenance services needed for the system usage. Also, since it has been identified from the KIIs that as some of the local officials of POs are not willing to work in the remote and isolated rural locations, the POs can consider employing and developing local youths as solar technicians. This will improve the customer service strategy of the POs as well as increase the customer satisfaction for promoting the adoption of SHS in the target market.

### 4.4. PPP investment in RE industry

Concerned Government bodies and IDCOL should take initiative to attract potential investors from national and international markets to venture in the energy sector of the country through private-public-partnership (PPP) establishments. Recently government is also promoting the diffusion and adoption of RET by making a policy that 50% of the TR-Kabikha fund, given for the development of local communities, should be utilized for solar electrification and 50% of the fund can be utilized in for other local initiatives. If larger power plants with solar energy can be developed and integrated with national grid, this will further benefit the mass population of the country by yielding greater domestic and industrial impact.

## 5. Conclusion

This study demonstrates the prospects of solar electrification in the distant rural villages of Bangladesh from the users' point of view. By analyzing the case of SHSs, we can show that villagers in off-grid locations can avail the energy services for household lightings and other low-load appliances like

fans, radio and mobile phone chargers. This study is a first attempt to examine the usage implications of renewable energy technology in the remote and coastal areas of Bangladesh. In this way, this study attempt to enrich the prevailing scholarly studies in the domain of the subject matter.

Realizing the inequality between urban and rural electrification status, this paper highlights that, off-grid power generation systems, like SHS, appear to be the most suitable alternative to provide the electricity services to the underserved rural communities. This has been addressed in this study which received less attention in the growing body of literature on solar electrification. This research asserts that to address the prevailing electricity crisis in remote rural communities, the alternative option for off-grid power supply like SHS comes up with the opportunity for providing light in darkness. Till now the solar electrification program in the country has yielded positive outcomes, primarily by enhancing the social status and living conditions of the remote rural communities and thus around 18 million beneficiaries are enjoying off-grid power connectivity.

Based on the study outcomes, the research can further be expanded to identify the factors that influences the adoption of RET in rural communities and examine the relationship among those variables to promote the acceptance of the technology in the target market. Findings of the study can be important for the participating organizations and supervisory institutions or developing managerial insights and technical capabilities to address the sustainability of the SHS ventures.

## References

Asaduzzaman, M., Yunus, M., Haque, A.E., Azad, A.A.M., Neelormi, S., and Hossain, M.A. (2013). Power from the sun: An evaluation of institutional effectiveness and impact of solar home systems in Bangladesh. *Final Report submitted to the World Bank, Bangladesh Institute of Development Studies*, Dhaka, Bangladesh.

Azimoh, C. L., Klintenberg, P., Wallin, F., and Karlsson, B. (2015). Illuminated but not Electrified: An Assessment of the Impact of Solar Home System on Rural Households in South Africa. *Applied Energy*, 155, 354-364.

Bangladesh Bureau of Statistics (BBS). (2016). Report of the Household Income and Expenditure Survey. Retrieve from: http://bbs.portal.gov.bd.

Bo, Y., Bao-Hua, W., and Fei-Ling, S. (2015). The Problems Facing Renewable Energy Use in Rural China. *Energy and Environment*, 26(3), 437-443.

Chakrabarty, S., and Islam, T. (2011). Financial Viability and Eco-efficiency of the Solar Home Systems (SHS) in Bangladesh. *Energy*, 36(8), 4821-4827.

Das, D. (2013). Is Solar Electrification a Sustainable Solution for Rural Electrification?. Learning from Field Experience. *Indian Journal of Energy*, 2(5), 121-128.

Hossain, M.F., Hossain, S., and Uddin, M.J. (2017). Renewable energy: Prospects and trends in Bangladesh. *Renewable and Sustainable Energy Reviews*, 44–49.

Infrastructure Development Company Ltd. (IDCOL). (2018). *Solar Home System Program. Solar Map*, Retrieve from: http://www.idcol.org/old/bd-map/bangladesh_map/.

Islam, M. S., Khan, A. M. H. R., Nasreen, S., Rabbi, F., and Islam, M. R. (2012). Renewable Energy: The Key to Achieving Sustainable Development of Rural Bangladesh. *Journal of Chemical Engineering*, 26(1), 9-15.

Islam, M. T., Shahir, S. A., Uddin, T. I., and Saifullah, A. Z. A. (2014). Current Energy Scenario and Future Prospect of Renewable Energy in Bangladesh. *Renewable and Sustainable Energy Reviews*, 39. 1074-1088.

Jitiwat, Y., and Tetsuo, T. (2013). A Survey of Remote Household Energy Use in Rural Thailand. *Energy Procedia*, 34, 64 – 72.

Kabir, A., Dey, H. S., and Faraby, H. M. (2010). Microfinance: The Sustainable Financing System for Electrification and Socio-economic Development of Remote Localities by Solar Home Systems (SHSs). *In Bangladesh. 4th Annual Systems Conference, IEEE*, 82-85.

Kassahun, Y. K., Toshio, M., and Mohammad T. I. (2015). Building Innovation System for the Diffusion of Renewable Energy Technology: Practices in Ethiopia and Bangladesh. *Procedia Environmental Sciences*, 28, 11 – 20.

Khan, J., and Arsalan, M. H. (2016). Solar Power Technologies for Sustainable Electricity Generation – A review. *Renewable and Sustainable Energy Reviews*, 55, 414–425.

Khan, T. (2017). Microfinance Interventions in Renewable Energy: Enhancing the Living Standard of Rural Households. *International Journal of Business and Management Study*, 4(1), 45-49.

Komatsu, S., Kaneko, S., Ghosh, P. P., and Morinaga, A. (2013). Determinants of User Satisfaction with Solar Home Systems in Rural Bangladesh. *Energy*, 61, 52-58.

Laufer, D., and Schäfer, M. (2011). The Implementation of Solar Home Systems as a Poverty Reduction Strategy—A Case Study in Sri Lanka. *Energy for sustainable Development*, 15(3), 330-336.

Mishra, P., and Behera, B. (2016). Socio-economic and Environmental Implications of Solar Electrification: Experience of Rural Odisha. *Renewable and Sustainable Energy Reviews*, 56, 953-964.

Momotaz, S. N., and Karim, A. M. (2012). Customer Satisfaction of the Solar Home System Service in Bangladesh. *World Journal of Social Sciences*, 2(7), 193-210.

Mondal, M. A. H., Kamp, L. M., and Pachova, N. I. (2010). Drivers, Barriers, and Strategies for Implementation of Renewable Energy Technologies in Rural Areas in Bangladesh—An Innovation System Analysis. *Energy Policy*, 38(8), 4626-4634.

Najmul, H. S. M., and Kumar, D. B. (2013). Present Status of Solar Home and Photovoltaic Micro Utility Systems in Bangladesh and Recommendation for Further Expansion and Upgrading for Rural Electrification. *Journal of Renewable and Sustainable Energy*, 5(4).

Palit, D. (2013). Solar Energy Programs for Rural Electrification: Experiences and Lessons from South Asia. *Energy for Sustainable Development*, 17(3), 270-279.

PSMP. (2005). Power sector master plan update. Ministry of Power, Energy and Mineral Resources, Dhaka, Bangladesh.

REP. (2008). Renewable Energy Policy. Ministry of Power, Energy and Mineral Resources, Dhaka, Bangladesh.

Sovacool, B. K., and Drupady, I. M. (2011). Summoning earth and fire: The energy development implications of Grameen Shakti (GS) in Bangladesh. *Energy*, 36(7), 4445-4459.

Twidell, J., and Weir, T. (2015). Renewable energy resources, Routledge.

World Bank. (2014). Electric power consumption (kWh per capita). Retrieved from: https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC

Wahi, R.R., and Ahsan, N.U. (2012). Feasibility Study of Solar Home System in Rural Areas of Bangladesh: Prospect, Progress and Challenges. *Proceedings of the Global Engineering, Science and Technology Conference*, 28-29 December 2012, Dhaka, Bangladesh.